A Mountain-Scale Flow Model for the Unsaturated Zone of Yucca Mountain, Nevada

Yu-Shu Wu, Guoping Lu, Keni Zhang, and G.S. Bodvarsson
Contact: Yu-Shu Wu, 510/486-7291, yswu@lbl.gov

RESEARCH OBJECTIVES

Large-scale 3-D flow models have played a critical role in characterizing and assessing the effects of hydrogeologic, thermal, and geochemical conditions in the unsaturated zone (UZ) at Yucca Mountain, Nevada, the proposed site of the future U.S. nuclear waste repository. Our work involves developing and refining the current mountain-scale UZ flow model developed for use in the current Total System Performance Assessment for License Application (TSPA-LA) in connection with Yucca Mountain.

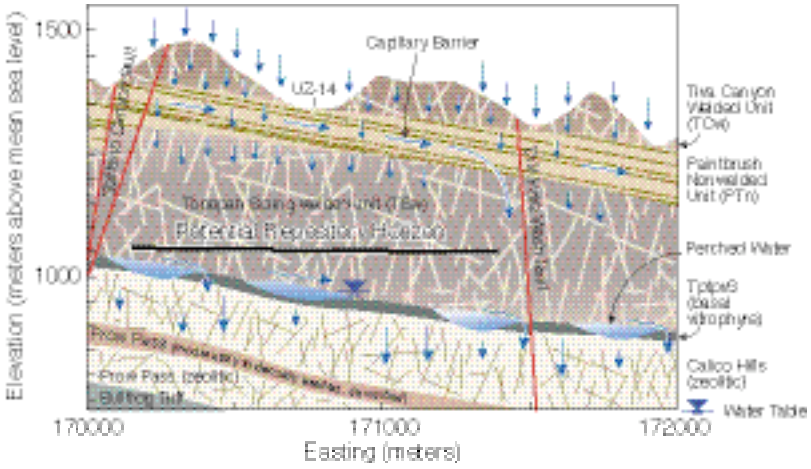

Figure 1. Schematic showing the conceptualized flow processes

APPROACH

The methodology employed in the ongoing development of the mountain-scale UZ flow model, based on the conceptual model (Figure 1), follows an iterative approach:

- Design a proper 3-D grid that incorporates complicated geological features of the site.
- Incorporate all available field data collected from the UZ.
- Calibrate the model using field-measured hydrological, pneumatic, thermal, and geochemical data.
- Conduct predictive studies and sensitivity analyses.

The modeling approach used in the UZ flow model is a dual-continuum mathematical formulation of coupled multiphase fluid and tracer transport through fractured porous rock, developed with the TOUGH2 code (a simulation code for multiphase, multicomponent flow and heat transfer).

ACCOMPLISHMENTS

Site-scale UZ flow models and submodels have shown the ability to match various types of field data on the model scale, including matrix liquid saturation and water potential, perched-water elevations, pneumatic data, geothermal gradients, and chloride data. The model has been used to (1) integrate all the available data from the UZ system into a single, comprehensive, and calibrated 3-D model for simulating the hydrological, thermal, and geochemical conditions at Yucca Mountain—for use in predicting system responses to ambient and future climate conditions; (2) quantify the moisture flow through the UZ, under present-day and estimated future climate scenarios; and (3) calculate times of radionuclide transport from the proposed repository level to the water table.

The site-scale UZ model has been successfully used to simulate past, present, and future hydrogeological, geothermal, and geochemical conditions and physical processes within the Yucca Mountain UZ. This model can be used to support various TSPA-LA activities.

SIGNIFICANCE OF FINDINGS

The mountain-scale UZ flow model generates 18 three-dimensional steady-state UZ flow fields, which have been used in direct calculations of radionuclide transport from the proposed repository to the water table, to support the TSPA-LA efforts. In addition, the UZ model results provide input parameters to various small-scale models and studies, such as drift-scale models, the mountain-scale thermal-hydrological model, and the UZ radionuclide transport model.

RELATED PUBLICATIONS

Wu, Y. S., L. Pan, W. Zhang, and G. S. Bodvarsson, Characterization of flow and transport processes within the unsaturated zone of Yucca Mountain, Nevada. Journal of Contaminant Hydrology, 54, 215–247, 2002.

Wu, Y. S., G. Lu, K. Zhang, G. Zhang, H.H. Liu, T. Xu, and E. L. Sonnenthal, UZ flow models and submodels. Report MDL-NBS-HS-000006 REV01, Lawrence Berkeley National Laboratory, CRWMS M&O, Berkeley, CA; Las Vegas, Nevada, 2003.

ACKNOWLEDGMENTS

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